

The 14 groundwater samples that were collected were analyzed for the oxidation-reduction potential (redox) parameters. Previous evaluations of temporal trends in groundwater VOC concentrations and mass indicated that natural attenuation processes were occurring at the Site. In December 1998, specific natural attenuation data were collected to supplement the preliminary natural attenuation assessment in order to characterize the processes contributing to the natural attenuation of VOCs observed at the Site.

Groundwater samples were collected from nine shallow monitoring wells and four deep monitoring wells using LFP and sampling techniques. The groundwater samples were analyzed for VOCs and oxidation-reduction (redox) parameters, including: field-measured dissolved oxygen (DO), oxidation-reduction potential (ORP), and dissolved (ferrous) iron, and laboratory analytical data for nitrate/nitrite, dissolved iron, dissolved manganese, sulfate and methane. Groundwater samples were also analyzed for VCM degradation products ethane and ethene. Total organic carbon (TOC) in groundwater was analyzed to provide data regarding the availability of a primary substrate for the reductive dechlorination of VOCs in the groundwater. The results for the field-measured and analytical parameters for the natural attenuation sampling are presented in Table 6.5.

6.3.1.1 NATURAL ATTENUATION BACKGROUND

The following section of this report presents a brief description of the theory of natural attenuation of Site-related VOCs and the assessment approach typically used in natural attenuation evaluations. The assessment approach presented herein is based primarily on the USEPA Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water (USEPA, September 1998), and is consistent with the evaluation requirements set forth under NJAC 7:26E-6.3.

The processes that control the natural attenuation of compounds in groundwater can be classified into two categories: non-destructive and destructive. Non-destructive processes result in reductions in compound concentrations over distance or time; destructive processes destroy the compound's structure resulting in reduced mass. Non-destructive natural attenuation processes include:

- i) dispersion and diffusion;
- ii) dilution;

- iii) sorption; and
- iv) volatilization.

Destructive natural attenuation occurs through degradation. Although degradation occurs by both non-biological (abiotic) and biological mechanisms (biotic), abiotic degradation rates are slow compared to those of biotic degradation. Biotic degradation is commonly known as biodegradation.

6.3.1.2 DISPERSION, DIFFUSION, AND DILUTION

A compound in water will move from an area of high concentration toward an area of lower concentration. In groundwater systems, compounds are transported by groundwater that is flowing at a velocity called the average linear velocity. This process is known as advective transport. However, groundwater flows at rates greater than, and less than, the average linear velocity because of the tortuous path that it must take through a porous medium. Because groundwater does not all move at the same velocity, mixing occurs along the flow path. This mixing is called mechanical dispersion. A compound in water also will move from an area of high concentration toward an area of lower concentration independent of advective groundwater flow. This process is called molecular diffusion. The effects of molecular diffusion and mechanical dispersion are combined in a term called hydrodynamic dispersion, which essentially describes the spreading, and thus dilution, of a compound in groundwater.

6.3.1.3 SORPTION

The term sorption is used to describe the overall effect of various processes that result in the binding of a compound to a solid particle. The processes that result in sorption include:

- i) adsorption, whereby a compound physically clings to a solid particle;
- ii) chemisorption, where a compound is incorporated onto a sediment, soil, or rock surface via a chemical reaction;
- iii) absorption, in which a compound disperses and/or diffuses into the soil, sediment, or rock matrix; and
- iv) cation exchange, in which positively charged particles (cations) are attracted to a negatively charged mineral surface and are held there by electrostatic forces (the

converse may also occur - i.e., negatively charged particles (anions) may be attracted and bound to positively charged surfaces by anion exchange).

Each of these processes results in the removal of a dissolved compound from solution.

6.3.1.4 VOLATILIZATION

Volatilization typically applies to organic compounds in the unsaturated zone and/or the saturated portion of groundwater table units (as opposed to confined units). Volatilization is a process by which compounds are transferred from the dissolved phase in groundwater to the vapor phase. This process is controlled by the solubility, molecular weight and vapor pressure of the compound, as well as the nature of the media through which the vapor passes. Volatilization is generally not significant in reducing chemical concentrations from the dissolved phase in saturated or confined units relative to other processes, although it may be more important for shallow or highly fluctuating groundwater tables.

6.3.1.5 BIODEGRADATION

Microbial biodegradation involves the utilization of carbon from an organic compound (the primary substrate) for microbial cell growth. As part of the biodegradation process, electrons are transferred from the primary substrate (electron donor) to an available electron acceptor. This transfer of electrons is defined as an oxidation-reduction (redox) reaction. The energy derived from this transfer of electrons is utilized by the soil microorganisms for cellular respiration.

Microbial biodegradation will only occur if suitable quantities of the primary substrate and electron acceptors are available for the necessary redox reactions. Organic matter is readily utilized as a primary growth substrate during microbial biodegradation. The biodegradation of this organic matter will often result in the cometabolic biodegradation of a secondary substrate, which is defined as an organic compound that does not undergo direct biodegradation, but is transformed to degradation products as a secondary reaction.

Fuel hydrocarbons (e.g., BTEX), landfill leachate and natural organic matter, serve as primary substrates for microbial biodegradation. Most chlorinated solvents, such as PCE, are secondary substrates that undergo cometabolic degradation during the biodegradation of the primary substrate (Baek and Jaffe, 1989; Freedman and Gossett,

1989; Fathepure and Boyd, 1988). Therefore, when chlorinated solvents are present in groundwater in the presence of an organic substrate, such as BTEX compounds, landfill leachate or natural organic carbon, the chlorinated solvents may be readily attenuated as a result of the extensive biodegradation of organic matter in groundwater.

Typical electron acceptors available in groundwater, in the order of those that release the greatest energy to those that release the least energy, are: dissolved oxygen, nitrate, manganese and iron coatings on soil, dissolved sulfate, and carbon dioxide. The sequential use of these electron acceptors occurs as groundwater redox potential becomes increasingly reduced during the biodegradation of organic compounds.

When groundwater becomes depleted of dissolved oxygen and nitrate, the conditions are conducive to the reduction and subsequent dissolution of iron and manganese oxides. Ferric iron (Fe^{3+}) typically exists as an oxide coating on soil and is relatively insoluble in groundwater. Ferric iron is used as an electron acceptor during microbial biodegradation where it is reduced to ferrous iron (Fe^{2+}), which exists primarily in the dissolved phase. Manganese (Mn) oxides are similarly utilized as electron acceptors under the appropriate redox conditions, and are reduced from the relatively insoluble Mn^{4+} form to dissolved manganese (Mn^{2+}). These biochemical reactions result in the mobilization of ferrous iron (Fe^{2+}) and manganese (Mn^{2+}) in groundwater. The mobilization of manganese will begin prior to that of iron because dissolved manganese (Mn^{2+}) is stable over a larger range of redox conditions than ferrous iron (Fe^{2+}). However, the concentration of dissolved iron in groundwater is often higher than that of manganese because soils typically have a higher iron content (Hem, 1985). Increased concentrations of dissolved iron in groundwater are indicative of sufficiently reducing conditions for the reductive dechlorination of chlorinated ethanes and ethenes.

With the long-term migration of organic contaminants in groundwater, a sequence of geochemical (or redox) zones of increasing redox potential will develop downgradient from the source area (Lyngkilde and Christensen, 1992b; Appelo and Postma, 1993). The sequence of these redox zones, in order of the closest to the farthest away from the source area, will be as follows:

- i) methanogenic zone;
- ii) sulfidogenic zone (sulfate-reducing);
- iii) ferrogenic zone [Fe^{3+} -reducing];
- iv) manganogenic zone [Mn^{4+} -reducing];
- v) nitrate-reducing zone; and
- vi) aerobic zone.

The extent of each individual redox zone is Site specific, and depends on substrate migration pathways, kinetics of redox processes, groundwater flow velocities, and the availability of various electron acceptors in groundwater. Ultimately, the Site-specific distribution of redox zones downgradient from the source area will control the natural attenuation of organic contaminants in impacted groundwater (Lyngkilde and Christensen, 1992a).

6.3.1.6 ASSESSMENT APPROACH

A weight-of-evidence approach is typically used to demonstrate the effectiveness of natural attenuation as a remedy at a site, allowing converging lines of evidence to be used to scientifically document the occurrence of natural attenuation. Relying on multiple lines of evidence increases the likelihood of successfully identifying the natural attenuation processes at a site (Wiedemeier et al., 1995; 1996).

McAllister and Chiang (1994) identify definitive indicators of natural attenuation to include:

- i) steady-state (stable) or receding plume conditions;
- ii) decreasing primary flow path concentrations; and
- iii) redox and geochemical indicators of biodegradation.

Each of the above indicators represents a distinct line of evidence that supports the occurrence of natural attenuation. In addition, the presence of daughter products is a very strong indicator of degradation. These distinct lines of evidence are considered individually in Section 6.3.2, and the results of these lines of evidence are considered together to present an overall picture of natural attenuation at the Site as presented in Section 6.3.3.

6.3.1.7 BIODEGRADABILITY OF VOCs

The chlorinated solvents PCE and VCM are the primary VOCs of interest in the groundwater at the Site. The following section of the report briefly discusses the biodegradation of chlorinated solvents.

Reductive dechlorination is the principal mechanism involved in the anaerobic biodegradation of chlorinated solvents (Klecka et al., 1996). Reductive dechlorination is a cometabolic process that occurs while the microorganisms are growing at the expense of an alternate carbon source, which acts as the primary substrate for biodegradation. Consequently, the rate of cometabolic degradation of chlorinated solvents is controlled by the availability of the primary substrate. The primary substrate may be native soil organic matter, or co-contaminants such as BTEX compounds.

PCE, the most chlorinated (and more highly oxidized) ethene, is susceptible only to anaerobic biodegradation. Most anaerobic biodegradation of chlorinated solvents occurs via a process called reductive dechlorination, in which chlorine atoms are removed one at a time. Through the reductive dechlorination process, PCE loses a chlorine atom and is transformed to TCE, which subsequently loses a chlorine atom and is transformed to DCE. The reductive dechlorination biodegradation pathway for PCE is presented on Figure 6.1.

VCM (the most reduced chlorinated ethene) is susceptible to both aerobic degradation (through oxidation) and anaerobic degradation (through reduction). Under aerobic conditions, VCM is readily oxidized to CO₂. Under anaerobic conditions, VCM may undergo reductive dechlorination, but at a slower rate than its precursors (e.g., PCE, TCE), and which may result in an accumulation of VCM under reduced conditions. Bradley and Chapelle (1996) documented the biologically-mediated anaerobic oxidation of VCM in natural aquifer sediments to CO₂, with Fe³⁺ serving as the primary electron acceptor. Anaerobic degradation of VCM by a combination of mineralization and reductive dechlorination has also been documented, resulting in the production of methane and ethene (molecular ratio of 2:1) (Barrio-Lage et al., 1990). Figure 6.1 shows the anaerobic degradation pathway for VCM to ethene and ethane.

6.3.2 EVIDENCE OF NATURAL ATTENUATION

6.3.2.1 GENERAL

Natural attenuation at the Site is suspected to occur by both non-destructive and destructive processes. Non-destructive natural attenuation processes such as dispersion, diffusion, dilution, sorption and volatilization generally apply to varying degrees to any site impacted by VOCs. The occurrence of destructive processes such as biodegradation are dependent on numerous environmental factors, and may or may not be significant at a given site.

The following indications of natural attenuation of organic compounds were evaluated:

- i) decreasing concentrations and mass of Site-related VOCs with time at individual monitoring well locations;
- ii) decreasing concentrations of Site-related VOCs along the groundwater flow path;
- iii) presence of degradation products in association with parent compounds;
- iv) presence of the complete dechlorination end-products of chlorinated ethanes and ethenes at individual monitoring well locations;
- v) redox and geochemical indicators of biodegradation; and
- vi) presence of an organic carbon supply to support microbial reductive dechlorination reactions.

This section of the report describes these lines of evidence as they pertain to the VOCs observed in the Site groundwater.

6.3.2.2 TEMPORAL CHANGES IN CHEMICAL CONCENTRATIONS

Historical concentrations at several individual monitoring wells demonstrate that concentrations of PCE and VCM are decreasing over time. Historical concentration versus time graphs for PCE, TCE, 1,2-DCE and VCM are presented on the figures included in Appendix C. Decreasing concentration trends are observed for PCE at monitoring wells MW-1S, MW-1D, MW-2S, MW-3D, MW-4S, MW-4D, MW-5S, MW-6S, MW-6D, and MW-8D, and for VCM at MW-2S, MW-3D, MW-4D, MW-6S, and MW-6D. VCM was not detected in any monitoring well sampled during the December 1998 quarterly event. At some monitoring wells, the decrease in PCE concentrations was accompanied by the presence of the PCE degradation products TCE and 1,2-DCE. While declining organic compound concentrations may be the result of physical processes such as dispersion and sorption, the corresponding presence of degradation products indicates that degradation is also occurring. The occurrence and significance of the presence of degradation products are further discussed in Section 6.3.2.4.

The observed decline in PCE and VCM concentrations at individual monitoring wells is supported by the results of mass balance calculations performed for PCE, TCE and VCM described in Section 4.3.2.2.

6.3.2.3 CURRENT CHEMICAL CONCENTRATION TRENDS ALONG FLOW PATH

The current distribution of PCE concentrations in shallow groundwater does not decrease along the flow path. In the shallow groundwater, the concentration of PCE based on the December 1998 sampling event is greatest at MW-6S (37 µg/L), which is located near the southern property boundary at the distant end of the groundwater flow path. VCM was not detected in any of the shallow monitoring wells during the December 1998 quarterly sampling event.

Based on the December 1998 data, PCE concentrations in the deep groundwater do decrease from a maximum concentration of 200 µg/L at MW-5D to 42 µg/L and ND1 µg/L at downgradient monitoring wells MW-6D and MW-4D, respectively, indicating some attenuation of PCE along flow path in the deep groundwater. VCM was not detected in any of the deep monitoring wells during the December 1998 quarterly sampling event.

6.3.2.4 PRESENCE OF DEGRADATION PRODUCTS

A key indicator of degradation is the presence of degradation products of PCE and VCM at monitoring wells located in and downgradient of the source areas. TCE and 1,2-DCE are degradation products of PCE (see Figure 6.1). Although VCM is also a degradation product of the PCE pathway, VCM was released at the Site; therefore, the presence of VCM is not considered to be an indicator of PCE degradation at this Site. As shown on the figures presented in Appendix C, the presence of PCE degradation products TCE and 1,2-DCE has been observed at monitoring wells MW-3S, MW-3D, MW-5S, MW-5D, MW-6S, MW-6D, MW-9S, and MW-9D.

The relative ratios of DCE isomers can be used to provide information regarding the origin of DCE in groundwater. There are three DCE isomers: 1,1-DCE, cis-1,2-DCE and trans-1,2-DCE. When DCE is released to the environment anthropogenically, the ratios of the three isomers typically are relatively equal. When DCE is produced through biodegradation of TCE, production of the cis-1,2-DCE isomer is favored over that of trans-1,2-DCE and 1,1-DCE. Examination of Table 6.6 shows that where 1,2-DCE is present, it is present as the cis-1,2-DCE isomer. 1,1-DCE and trans-1,2-DCE are non-detect. This indicates that 1,2-DCE, where present, is most likely the product of biodegradation.

The presence of ethane and ethene provides an indication that VCM is undergoing reductive dechlorination, which produces ethene and subsequently ethane (see Figure 6.1). In December 1998 groundwater samples were collected for the analysis of ethene and ethane. The analytical data for ethane and ethene indicate that ethane is present only at TW-20 (0.9 µg/L). The predominant absence of ethane and ethene in the groundwater indicates that degradation of VCM by reductive dechlorination is not significant.

6.3.2.5 REDOX INDICATORS OF BIODEGRADATION

The groundwater data from the natural attenuation samples collected in December 1998 provided analytical results for the following redox parameters: nitrate (NO_3^-)/nitrite (NO_2^-), dissolved manganese (Mn^{2+}), dissolved iron (Fe^{2+}), sulfate (SO_4^{2-}), sulfides (S^{2-}), and methane (CH_4). During collection of the groundwater samples by LFP techniques, field measurements of dissolved oxygen (DO) and oxidation-reduction (redox) potential (ORP) were taken. The field and analytical parameter data are presented in Table 6.5.

The DO and ORP data are erratic for some monitoring wells. Concentrations above the solubility limit of oxygen in water (approximately 11 mg/L at 10°C) are reported at monitoring well MW-1S. Also, the presence of substantial DO and high ORP values in groundwater is sometimes reported where other analytical parameters indicated anaerobic conditions (i.e., absence of nitrate and nitrite, and presence of dissolved manganese, iron and methane). Field measurement of DO is very sensitive and is often subject to sampling or equipment error. In determining the validity of a reported DO concentration, the oxygen solubility limit was considered, as well as the consistency of the reported DO or ORP value with other oxygen-sensitive parameters, such as nitrate, nitrite, Mn^{2+} , Fe^{2+} , and methane. Where reported DO concentrations are contradicted by multiple indicators of reduced conditions, the DO value is rejected.

The distribution of sulfate concentrations appears to be related to an upgradient source area and obscure the verification of sulfate reduction in Site groundwater. Therefore, the distinction between the ferrogenic and sulfidogenic zones is not clear. The elevated sulfate in Site groundwater may be due to the presence of a gypsum facility located upgradient of the Site.

The relative concentrations of redox indicator data were used to identify the dominating redox processes as expressed by the electron acceptor being reduced by the biodegradation of organic carbon. Based on the redox data presented in Table 6.5, the deep groundwater data are oxic (aerobic). Groundwater from three of the four deep

wells is indicative of an aerobic environment, as indicated by the relatively high field DO and ORP measurements, and low or non-detect values for dissolved manganese, dissolved iron and methane. Redox conditions at MW-4D are mildly post-oxic and are indicative of nitrate-reducing activity. Although an aerobic environment is conducive to the chemical oxidation of VCM, degradation of PCE is not typically favored under aerobic or nitrate-reducing conditions.

Analysis of the redox parameter data for shallow groundwater indicates that redox conditions in the shallow wells are more strongly reducing. Of the nine shallow monitoring wells sampled, six samples indicate reducing conditions in the manganogenic (MW-5S), ferrogenic (MW-9S, MW-10), and methanogenic (MW-4S, MW-6S, TW-20) phases. Each of these monitoring locations is located downgradient of source areas identified at the Site. The strong reducing nature of these shallow wells is based on relatively low DO and ORP measurements, and elevated concentrations of redox indicators such as dissolved manganese, dissolved iron, and methane. Aerobic conditions are indicated at monitoring wells MW-2S and MW-11. Redox conditions at MW-1S are ambiguous based on the data provided. The extent of the strong reducing groundwater is presented on Figure 6.2. Reducing conditions in the ferrogenic to methanogenic are conducive to the reductive dechlorination of PCE and TCE. Degradation of VCM occurs in some, but not all, reduced environments.

6.3.2.6 PRESENCE OF AN ORGANIC CARBON SUPPLY

The biodegradation of VOCs at the Site is the result of cometabolic processes in which the VOCs do not provide a carbon source for the microbial population; therefore, a direct carbon source is required for the cometabolism of the VOCs. This carbon source, which is called the primary substrate, is often measured as total organic carbon (TOC). Based on the concentrations of TOC in the Site groundwater, the TOC content in the shallow groundwater is expected to be sufficient to sustain biodegradation activity. The deep groundwater is predominantly deficient in TOC. TOC was detected above 1,000 µg/L in only one deep groundwater sample (MW-4D).

The presence of TOC in the shallow groundwater correlates well with redox indicators of reducing conditions and the presence of degradation products. This may indicate that the occurrence of reductive dechlorination of PCE and VCM in the Site groundwater is being controlled by the availability, or lack, of primary substrate in the form of TOC in Site groundwater.

6.3.3 SUMMARY

A review of the data presented herein indicates that some of the natural attenuation of PCE and VCM is occurring via biological processes at the Site. However, the contribution of destructive natural attenuation processes is nominal and very localized. The natural attenuation assessment resulted in the following observations:

- i) declining concentration and mass of PCE and VCM over time was observed at all individual monitoring wells throughout the Site except for PCE in well MW-5D;
- ii) PCE degradation products (TCE and 1,2-DCE) were observed in some shallow monitoring wells, indicating that degradation of PCE is occurring in localized areas;
- iii) VCM degradation products (ethane and ethene) were observed at one shallow monitoring location only, indicating that biodegradation of VCM by reductive dehalogenation is currently not prevalent;
- iv) the distribution of redox parameters indicates an area of reducing (manganogenic, ferrogenic, and methanogenic) conditions in the shallow groundwater, and that conditions in the deep groundwater are aerobic and nitrate-reducing;
- v) an organic carbon supply exists in shallow groundwater, and is essentially non-existent in deep groundwater; and
- vi) biodegradation may be limited by the poor availability of TOC.

The redox data indicate that conditions in some shallow groundwater are predominantly ferrogenic reducing to methanogenic and that conditions in the deep groundwater are primarily aerobic. This indicates that conditions in some shallow groundwater are conducive to the biodegradation of highly chlorinated solvents such as PCE. Degradation of PCE to TCE and 1,2-DCE is also indicated at some monitoring wells in the reduced shallow groundwater. The predominance of cis-1,2-DCE relative to trans-1,2-DCE and 1,1-DCE indicates that the 1,2-DCE present in the groundwater is a biodegradation product. Although biodegradation of VCM has been reported in some reduced environments (e.g., ferrogenic), the overall absence of ethene and ethane in the shallow aquifer indicates that anaerobic biodegradation of VCM is not currently occurring at a significant rate in the shallow groundwater.

The redox data from the deep groundwater samples indicate that the deep groundwater is aerobic and nitrate-reducing, which is not conducive to the biodegradation of PCE. Given the general absence of TOC in deep groundwater at the Site, it is unlikely that a

reducing environment conducive to the biodegradation of PCE will develop without intervention.

Although there is evidence of limited biodegradation activity in the shallow groundwater, the results of this natural attenuation assessment indicate that the reductions in PCE and VCM concentrations and mass over time are primarily due to non-destructive natural attenuation processes.

6.3.4 TW-20 AREA CHEMICAL PRESENCE DELINEATION

PCE and TCFM have been recently detected in monitoring well TW-20. Well TW-20 is screened across the entire upper aquifer (i.e., from 6 to 31 feet bgs). The EPA expressed concern with the lack of information on the downgradient extent of the plume in this area. To delineate the chemical presence in the groundwater in the area of TW-20, two additional groundwater monitoring wells were installed at the locations shown on Figure 5.8. MW-10 was installed to assess the extent of VOC migration downgradient of TW-20, and MW-11 was installed to delineate the width of impacted groundwater cross-gradient to TW-20. The wells were installed as described in Section 5.3.

The two wells were installed to monitor the entire saturated thickness of the Shallow Aquifer similar to well TW-20. Well permits were secured prior to the installation of the wells. Well purging and sample collection procedures were consistent with the LFP procedures.

Monitoring wells MW-10 and MW-11 were analyzed for VOCs. The only compound detected in these samples, PCE at MW-11 at 4 µg/L, is compared to the NJDEP and EPA concentrations below:

<i>Volatile</i>	<i>NJDEP Class II-A Criteria (µg/L)</i>	<i>EPA MCL (µg/L)</i>	<i>MW-10</i>	<i>MW-11</i>
PCE	1	5	ND	4J

Notes:

ND - Not detected at a concentration of 5 µg/L.

J - Estimated concentration.

As described above, monitoring wells MW-10 and MW-11 were installed to delineate chemical presence in the groundwater in the area of TW-20. Samples collected from TW-20 in December 1998 as part of the quarterly monitoring program for the Site had a concentration of 29 µg/L for PCE and 10 µg/L for TCFM. The results from the new monitoring wells show that groundwater cross-gradient of TW-20 contains only a trace of PCE. The groundwater from MW-10 does not appear to have been impacted by the chemicals from the Site.

7.0 IDENTIFIED AREAS OF CONCERN AND PROPOSED ADDITIONAL INVESTIGATIVE ACTIVITIES

7.1 IDENTIFIED AREAS OF CONCERN

The evaluation of the SI investigative results presented in Section 6.0 has identified the following as areas of concern:

- i) PCBs in the Resin Ditch;
- ii) the groundwater in the shallow aquifer underlying the Site, particularly the PCE presence in the area of well MW-5D; and
- iii) TPH presence in the surficial soil (0.0 to 0.5 feet bgs) in the area of the AST valving.

7.2 RESIN DITCH

The PCB results on Figures 4.2, 5.2, and 5.3 show the following with respect to delineating the PCB presence to a concentration of 0.49 mg/kg in the Drain Ditch:

- i) Centerline - An additional sample needs to be collected and analyzed from sample location RD-2 at greater depth (e.g., 5.5 to 6.0 feet bgs). The PCB concentration of 0.71 mg/kg at sample location RD-3 is only slightly above the delineation target of 0.49 mg/kg and therefore, it is believed that an additional sample at greater depth is not needed;
- ii) Western Portion - An additional sample needs to be collected and analyzed from each of sample locations RD-1w, RD-2w, RD-3w, and RD-5w at greater depth (e.g., 2.5 to 3.0 feet bgs); and
- iii) Eastern Portion - An additional sample needs to be collected and analyzed from each of sample locations RD-1e, RD-2e, RD-3e, and RD-5e at greater depth (e.g., 2.5 to 3.0 feet bgs).

In addition to the above, another line of samples should be collected from another 5 feet farther to the west of the current western portion and east of the current eastern portion adjacent to the five sample stations RD-1 to RD-5. The sample interval at each location should include 0.0 to 0.5 and 1.0 to 1.5 feet bgs.

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- ii) Western Portion - An additional sample needs to be collected and analyzed from each of sample locations RD-1w, RD-2w, RD-3w, and RD-5w at greater depth (e.g., 2.5 to 3.0 feet bgs); and
- iii) Eastern Portion - An additional sample needs to be collected and analyzed from each of sample locations RD-1e, RD-2e, RD-3e, and RD-5e at greater depth (e.g., 2.5 to 3.0 feet bgs).

In addition to the above, another line of samples should be collected from another 5 feet farther to the west of the current western portion and east of the current eastern portion adjacent to the five sample stations RD-1 to RD-5. The sample interval at each location should include 0.0 to 0.5 and 1.0 to 1.5 feet bgs.

A summary of the proposed samples is listed in Table 7.1.

Upon receipt of the PCB data from the additional sampling of the Resin Ditch, it is expected that the delineation of the on-Site PCB presence will be sufficient to develop an appropriate remediation plan in conjunction with the NJDEP.

7.3 SURFACE WATER (NJAC7:26E-3.8)

Based on the historic information presented in Section 4.2.4, it was concluded that there is no potential risk to human health from exposure to surface water. The ecological assessment included in Appendix J identified that:

- i) VOCs in the sediments were not detected and thus are not considered chemicals of concern in Bustleton Creek sediments;
- ii) the PCB concentrations in the three most downstream sample locations exceeded the NJDEP PCB screening level; and
- iii) the risk from PCBs is likely minimal.

To clearly demonstrate that VOCs are not chemicals of concern in Bustleton Creek surface water, one round of surface water samples will be collected from approximately the same locations as the sediment samples. In addition, one sample will be collected at a location approximately 1,000 feet further upstream of sample location BC-4 (or at the most upstream location where water is available, see Figure 5.6). The samples will be collected during a low tide event to prevent the possibility of flow reversal (i.e., Bustleton Creek surface water recharging the shallow aquifer) which may occur during high tide. It was observed that at low tide, Bustleton Creek is essentially a mud flat with the majority of water depths on the order of 6± inches and a few deeper areas with a water depth on the order of 1± foot. Thus, composite samples with depth are not possible nor practical. The samples will be collected as follows:

- i) prior to sample collection, the Creek characteristics (e.g., depth estimated velocity and flow, Creek water levels, tidal stage) will be recorded in a field book;
- ii) sample collection will proceed from the downstream to upstream locations;
- iii) the sample will be collected at a depth mid-way between the surface water level of the Creek bed where the water depth is approximately 1 foot or greater deep. This depth was selected to minimize the potential of sediment presence in the sample and increase the potential to observe the contribution of groundwater inflow to the Creek surface water;

- iv) the samples will be collected by wading into the Creek and positioning the sample bottle upstream relative to stream flow and the wader; and
- v) the samples will be collected by inserting the open laboratory decontaminated sample bottle inverted into the water. The sample bottle will then be slowly uprighted to allow the bottle to fill. The bottle will be capped prior to bringing the bottle to the surface.

The above procedures are consistent with those presented in the "Field Sampling Procedures Manual" dated May 1992.

7.4 GROUNDWATER

The following wells (i.e., MW-10, MW-11, TW-20, and PW-2) will be sampled during future quarterly groundwater sampling events, starting in March 1999 for the same parameters as the other wells already included in the quarterly sampling events. These wells will be sampled and analyzed for the next four quarters, using normal sampling procedures for the monitoring wells (higher flow purging and no filtration). After the December 1999 quarterly event, the analytical results will be reviewed to determine which of the above wells, if any, need to continue to be sampled and analyzed.

In addition to the continuation of groundwater monitoring, it would be appropriate to perform a focused assessment of the chemical presence that continues to exist at the MW-5D location. The results of the assessment will be shared with the NJDEP with the intent of developing an appropriate course of action to address this condition.

8.0 REFERENCES

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